



# Funding and Strategic Alignment Guidance for Infusing Small Business Innovation Research Technology Into Aeronautics Research Mission Directorate Programs and Projects for 2015

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## **Abstract**

This report is intended to help NASA program and project managers incorporate Small Business Innovation Research/Small Business Technology Transfer (SBIR)/(STTR) technologies into NASA Aeronautics Research Mission Directorate (ARMD) projects. Other Government and commercial projects managers can also find this useful.

## **Introduction**

Incorporating Small Business Innovation Research (SBIR)-developed technology into NASA projects is important, especially given the Agency's limited resources for technology development. The program's original intention was for technologies that had completed Phase II to be ready for integration into NASA programs, however, in many cases there is a gap between Technology Readiness Levels (TRLs) 5 and 6 that needs to be closed.

After SBIR Phase II projects are completed, the technology is evaluated against various parameters and a TRL rating is assigned. Most programs tend to adopt more mature technologies—at least TRL 6 to reduce the risk to the mission rather than adopt TRLs between 3 and 5 because those technologies are perceived as too risky. The gap between TRLs 5 and 6 is often called the “Valley of Death,” (Figure 1) and historically it has been difficult to close because of a lack of funding support from programs. Several papers have already suggested remedies on how to close the gap (Refs. 1 to 4).

## **SBIR Solicitation Process**

Understanding how the SBIR solicitation process works should help small businesses and Aeronautics Research Mission Directorate (ARMD) project managers form partnerships to incorporate SBIR technologies into NASA programs and projects. For example, when ARMD program managers identify specific SBIR subtopics that are likely to generate technologies that could apply to their programs or projects, the SBIR office would provide information about previously developed technologies that could be incorporated into their work. Small business principal investigators (PIs) would also benefit from understanding NASA program and project needs, thus increasing the likelihood that the technologies they developed will be infused into ARMD projects. The fiscal year (FY) 2015 and 2014 solicitations are posted at <http://sbir.gsfc.nasa.gov/solicitations>.

Integrating SBIR-developed technology into NASA programs and projects is important, especially given the Agency's limited resources for technology development. The SBIR program's original intent was for technologies that had completed Phase II to be ready for integration into NASA programs. Now the SBIR program supports its small business partners with three post-Phase II options that focus on creating opportunities for commercialization as well as technology integration. The Phase II Enhancement

		TRL	Description
SBIR Phases I and II	Basic research	1	Basic scientific/engineering principles observed and reported
	Feasibility research	2	Technology concept, application, and potential benefits formulated (candidate system selected)
	Feasibility research	3	Analytic and/or experimental proof-of-concept completed (breadboard test)
	Technology development	4	System concept observed in laboratory environment (candidate system selected)
Technology demonstration "Valley of Death"	Technology development	5	System concept tested and potential benefits substantiated in a controlled relevant environment
	System development	6	Prototype of system concept is demonstrated in a relevant environment
System development	System development	7	System prototype is tested and potential benefits substantiated more broadly in a relevant environment
	Operational verification	8	Actual system constructed and demonstrated with benefits substantiated in a relevant environment
	Operational verification	9	Operational use of actual system tested with benefits proven

Figure 1.—Technology Readiness Levels (TRLs).

(Phase II–E), Phase II Expanded (Phase II–X), and Commercialization Readiness Program (CRP) options also provide opportunities for Phase II technologies to be integrated and tested in the NASA system platform or in the space environment.

The three post-Phase II options, which typically last between 6 and 36 months, create more opportunities to advance technology maturity, reduce associated risks, and increase the likelihood for integrating technology into NASA, Department of Defense (DoD), or external entity programs.

- **Phase II–E:** This option advances Phase II innovations by extending existing Phase II contracts. Under Phase II–E extensions, NASA SBIR will match, investments in technology development that small businesses secure from eligible non-NASA SBIR third parties on a dollar-for-dollar basis. The minimum matching investment is \$25,000 and the maximum is \$150,000, extending projects by 6 to 12 months.
- **Phase II–X:** This option establishes a strong and direct partnership between the SBIR program and NASA programs and projects undertaking new technology development. Under Phase II–X expansions, NASA SBIR will double the funding that small businesses secure from non-SBIR NASA programs or projects. The minimum investment that NASA SBIR will double is \$75,000 and the maximum is \$250,000. Expanded projects last between 12 and 24 months.
- **CRP:** This option accelerates transition of SBIR-developed technologies into NASA applications. Projects that request SBIR funding under the CRP option must (1) involve a technology that entered into either a Phase I or Phase II contract and (2) identify how more SBIR funding would accelerate development in response to NASA program or project needs. The minimum matching investment is \$100,000 and the maximum is \$1.5 million, extending projects by 24 to 36 months.

Table I summarizes the three post-Phase II options.



TABLE I.—NASA SBIR POST-PHASE II FUNDING OPTIONS

Criteria	Phase II–E	Phase II–X <sup>a</sup>	CRP
Purpose	Advance SBIR technology by extending current Phase II contracts	Establish partnerships between NASA programs and projects and non-SBIR companies	Accelerate transition of SBIR-developed technologies into NASA applications
Funding source	Any eligible non-NASA SBIR third party	NASA program or project	Either eligible NASA program or project or non-NASA SBIR third party
Minimum, dollars	\$25,000	\$75,000	\$0
Maximum, dollars	\$150,000	\$250,000	\$0
SBIR match	1:1	2:1	Up to \$1,500,000
Performance period, months	6 to 12	12 to 24	24 to 36

<sup>a</sup>Beginning in FY 2012.

#### A1 Air Vehicle Technology

A1.01 Structural Efficiency-Hybrid Nanocomposites  
A1.02 Aerodynamic Efficiency Drag Reduction Technology  
A1.03 Low Emissions Propulsion and Power  
A1.04 Quiet Performance  
A1.05 Physics-Based Conceptual Aeronautics Design Tools  
A1.06 Vertical Lift  
A1.07 Efficient Propulsion and Power  
A1.08 Ground Testing and Measurement Technologies

#### A2 Integrated Flight Systems

A2.01 Flight Test and Measurements Technologies  
A2.02 Unmanned Aircraft Systems Technology

#### A3 Airspace Operations and Safety

A3.01 Advanced Air Traffic Management Systems Concepts  
A3.02 Autonomy of the National Airspace System  
A3.03 Future Aviation Systems Safety

Figure 2.—Aeronautics Research Mission Directorate topics and subtopics for FY 2015 Phase I.

## Fiscal Year 2015 Phase I SBIR Topic and Subtopic Summaries

Topics and subtopics for all directorates are listed in Chapter 9 of the FY15 Phase I SBIR solicitation. ARMD topics and subtopics are shown in Figure 2 and ARMD solicitation descriptions follow.

### Topic A1 Air Vehicle Technology

#### A1.01 Structural Efficiency-Hybrid Nanocomposites

Two of the primary goals of the Advanced Air Vehicles program are safety and efficiency, which can be achieved simultaneously through designer materials tailored for future aircraft structures. The SOA for lightweight structures are carbon fiber reinforced polymeric composites which make up approximately 50% of the weight of Boeing's 787. Adoption of all-carbon nanotube (CNT) composites to exploit their potential for enhancing structural efficiency is viewed as too far term, given the current state of CNT technology maturation. Hybrid composites enable improved mechanical properties such as interlaminar

strength, while simultaneously increasing electrical and thermal conductivity to enable features such as lightning strike protection, embedded sensing, etc.

### **A1.02 Aerodynamic Efficiency Drag Reduction Technology**

The challenge of energy-efficient flight has at its foundation aerodynamic efficiency, and at the foundation of aerodynamic efficiency is low drag. Drag can be broadly decomposed into four components: viscous or skin friction drag, lift-induced drag, wave or compressibility drag, and excrescence drag due to various protruding items such as antennae, wipers, lights, etc. The relative impact of these four forces depends upon the targeted flight regime and vehicle-specific design requirements. The first force, however, viscous skin friction, stands out as particularly significant across most classes of flight vehicles and effective measures for its control would have a major impact of flight efficiency. In particular, supersonic, low-boom flight and new generations of energy-efficient subsonic transport airplanes including high L/D strut-braced designs, the blended wing body (BWB), so called “double-bubble” designs and other concepts with large expanses of surface area would benefit from effective viscous drag control.

### **A1.03 Low Emissions Propulsion and Power**

Supports electric propulsion of transport aircraft, including turboelectric propulsion (turbine prime mover with electric distribution of power to propulsors) and various hybrid electric concepts, such as gas turbine engine and battery combinations. Turboelectric propulsion for transport aircraft applications will require components with high specific power (hp/lb or kW/kg) and high efficiency, and cryogenic and superconducting components will likely be required. The cryogenic components of interest include fully superconducting generators and motors (i.e., superconducting stators as well as rotors), cryogenic inverters and active rectifiers, and cryocoolers.

### **A1.04 Quiet Performance**

Improvements in noise prediction, acoustic and relevant flow field measurement methods, noise propagation and noise control are needed for subsonic, transonic and supersonic vehicles targeted specifically at airframe noise sources and the noise sources due to the aerodynamic and acoustic interaction of airframe and engines. Innovative source identification techniques for airframe (e.g., landing gear, high lift systems) noise sources, including turbulence details related to flow-induced noise typical of separated flow regions, vortices, shear layers, etc.

### **A1.05 Physics-Based Conceptual Aeronautics Design Tools**

Investigates the potential of advanced, innovative propulsion and aircraft concepts to improve fuel efficiency and reduce the environmental footprint of future generations of commercial transports across the breadth of the flight speed regimes. Propulsion systems such as open rotors and hybrid-electric propulsion, are viewed as potential options for helping meet aggressive, long range (i.e., 'N+3' timeframe) emission reduction targets. Accurate representation of the propulsion system is critical in confidently assessing the potential of a concept. Conceptual design and analysis of unconventional propulsion concepts and technologies is used for technology portfolio investment planning, development of advanced concepts to provide technology pull and independent technical assessment of new concepts.

### **A1.06 Vertical Lift**

The use of small vertical lift UAVs has increased in recent times with many civilian missions being proposed, including autonomous surveillance, mapping, etc. Much of the current research associated with these vehicles has been in the areas of electric propulsion, batteries, small sensors and autonomous control laws, while very little attention has been paid to their acoustic signature. The generation and propagation of noise associated with this small class of vertical lift UAVs are not well understood and validated prediction tools do not currently exist. The objective of a proposed effort would be to develop tools for the modeling and prediction of the high frequency acoustics for small vertical lift UAVs, such as quad-copters, coaxials, ducted fan rotors, etc.

### **A1.07 Efficient Propulsion and Power**

Focuses on propulsion controls and dynamics. Typical current operating engine control logic is designed using SISO (Single Input Single Output) PI (Proportional+Integral) control. The control logic is designed to provide minimum guaranteed performance while maintaining adequate safety margins throughout the engine operating life. Additionally, the control logic indirectly provides control of variables of interest such as Thrust, Stall Margin, etc. since these variables cannot be measured or are not measured in flight because of restrictions on sensor cost/placement/reliability, etc. to develop all aspects of control systems to enable safe operation of low emissions combustors throughout the engine operating envelope. Low emission combustors are prone to thermo-acoustic instabilities. So far NASA research in this area has focused on modulating the main or pilot fuel flow to suppress such instability. Advanced, ultra-low emissions combustors utilize multi-point (multi-location) injection to achieve a homogeneous, lean fuel/air mixture.

### **A1.08 Ground Testing and Measurement Technologies**

Develops innovative tools and technologies that enhance testing and measurement capabilities, improve ground test resource utilization and efficiency, and provide capability sustainment. Where possible, the tools and technologies should be applicable for the broad national scope of government, commercial, and university capabilities.

## **Topic A2 Integrated Flight Systems**

### **A2.01 Flight Test and Measurements Technologies**

NASA continues to see flight research as a critical element in the maturation of technology. This includes developing test techniques that improve the control of in-flight test conditions, expanding measurement and analysis methodologies, and improving test data acquisition and management with sensors and systems that have fast response, low volume, minimal intrusion, and high accuracy and reliability. By using state-of-the-art flight test techniques along with novel measurement and data acquisition technologies, NASA and the aerospace industry will be able to conduct flight research more effectively and also meet the challenges presented by NASA and industry's cutting edge research and development programs

### **A2.02 Unmanned Aircraft Systems Technology**

Unmanned Aircraft Systems (UAS) offer advantages over manned aircraft for applications which are dangerous to humans, long in duration, require great precision, and require quick reaction. Examples of such applications include remote sensing, disaster response, delivery of goods, agricultural support, and

many other known and yet to be discovered. In addition, the future of UAS promises great economic and operational advantages by requiring less human participation, less human training, an ability to take-off and land at any location, and the ability to react to dynamic situations.

## **Topic A3 Integrated Flight Systems**

### **A3.01 Advanced Air Traffic Management Systems Concepts**

This subtopic addresses user needs and performance capabilities, trajectory-based operations, and the optimal assignment of humans and automation to air transportation system functions, gate-to-gate concepts and technologies to increase capacity and throughput of the National Airspace System (NAS), and achieving high efficiency in using aircraft, airports, en route and terminal airspace resources, while accommodating an increasing variety of missions and vehicle types, including full integration of Unmanned Aerial Systems (UAS) operations.

### **A3.02 Autonomy of the National Airspace System**

Develop concepts or technologies focused on increasing the efficiency of the air transportation system within the mid-term operational paradigm (2025 to 2035 time frame), in areas that would culminate in autonomy products to improve mobility, scalability, efficiency, safety, and cost-competitiveness.

### **A3.03 Future Aviation Systems Safety**

The Aeronautics Research Mission Directorate (ARMD) will be concluding the successful Aviation Safety Program (AvSP). The newly expanded Airspace Operations and Safety Program (AOSP) will be succeeding AvSP's significant achievements and stepping up to lead the ARMD research in the area of Real-Time System-Wide Safety Assurance (RSSA). ARMD's Real-Time System-Wide Safety Assurance RSSA will be focused towards a future National Airspace System where a gate-to-gate trajectory-based system capability exists that satisfies a full vision for NextGen and beyond. The ultimate vision for RSSA would enable the delivery of a progression of capabilities that accelerate the detection, prognosis and resolution of system-wide threats

## **Fiscal Year 2014 Phase II SBIR Topic and Subtopic Summaries**

Topics and subtopics for all directorates are listed in Chapter 9 of the FY14 Phase II SBIR solicitation. ARMD topics and subtopics are shown in Figure 3 and ARMD solicitation descriptions follow.

## **Topic A1 Aviation Safety**

### **A1.01 Aviation External Hazard Sensor Technologies**

Explores new and improved sensors and sensor systems for the detection and monitoring of hazards to aircraft before they are encountered. Approaches that use multiple sensors in combination to improve hazard detection and quantification of hazard levels are also of interest. With regard to hazardous lightning conditions, the emphasis is not on remote detection, but rather on developing systems that make aircraft more robust in a lightning environment or provide in-flight damage assessment or other hazard mitigating benefits. The scope of this subtopic does not include human factors and focused development of human interfaces, including displays and alerts. Primary emphasis is on airborne applications, but in some cases the development of ground-based sensor technology may be supported.

## Topics and Subtopics

### A1 Air Aviation Safety

- A1.01 Aviation External Hazard Sensor Technology
- A1.02 Inflight Icing Hazard Mitigation Technology
- A1.03 Real-Time Safety Assurance under Unanticipated and Hazardous Conditions
- A1.04 Prognostics and Decision Making
- A1.05 Identification of Sequences of Atypical Occurrences in Massive Heterogeneous Datasets Representing the Operation of a System of Systems

### A2 Unmanned Aircraft Systems

- A2.01 Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Research

### A3 Air Vehicle Technology

- A3.01 Structural Efficiency-Aeroservoelasticity
- A3.02 Quiet Performance
- A3.03 Low Emissions/Clean Power
- A3.05 Physics-Based Conceptual Design Tools
- A3.06 Rotorcraft
- A3.07 Propulsion Efficiency-Propulsion Materials and Structures

### A4 Ground and Flight Test Techniques and Measurement

- A4.01 Ground Test Techniques and Measurement Technologies

Figure 3.—Aeronautics Research Mission Directorate topics and subtopics for FY 2014 Phase II.

#### **A1.02 Inflight Icing Hazard Mitigation Technology**

Prevents hazardous in-flight conditions by addressing detection, measurement, and/or the mitigation of the hazards of flight into super-cooled liquid water clouds and flight into regions of high mass concentrations of ice crystal. Measurement and detection can include measurement of the phase (ice or liquid), measurement of the mass of the droplets, or 3-D measurements of ice density.

#### **A1.03 Real-Time Safety Assurance Under Unanticipated and Hazardous Conditions**

Assuring safety of flight under uncertain, unanticipated, and multiple hazards is a core requirement for aircraft loss of control prevention and for safety-assured autonomous aircraft operations. Sources of hazards include adverse onboard conditions (e.g., system failures, vehicle impairment or damage), external disturbances (e.g., turbulence, inclement weather, wake vortices), and abnormal flight conditions (e.g., abnormal attitudes/rates, unsafe/abnormal flight trajectories, stall/departure).

#### **A1.04 Prognostics and Decision Making**

Topics address aspects of the following areas (1) Remaining Useful Life (RUL) prediction techniques that address a set of fault modes for a device or component, for example by modeling the physics of the most critical fault modes and using (typically less accurate) data-driven methods for the remainder, and (2) Physics-based damage propagation models for one or more relevant aircraft subsystems such as airframe structures, avionics, electrical power systems, and electronics. Methods for damage propagation in composite structures are of a particular interest. Proposals that focus on technologies envisioned for next generation aircraft are strongly encouraged.

### **A1.05 Identification of Sequences of Atypical Occurrences in Massive Heterogeneous Datasets Representing the Operation of a System of Systems**

The focus of this effort will be from the aircraft-level to fleet level and above. As such, the successful proposal will develop validated predictive analytics to uncover systemic human-automation interaction issues that manifest at a much broader level than those incidents that occur within a single flight or for a single aircraft. Real data from a defunct airline will be made available as GFE (government furnished equipment), representing the interactions between humans and automation found on flight systems, data from aircraft as well as supporting ground-based systems.

## **Topic A2 Unmanned Aircraft Systems**

### **A2.01 Unmanned Aircraft Systems Integration in the National Airspace System Research**

Unmanned Aircraft Systems (UAS) are needed to fly in the National Airspace System (NAS) to perform missions for the National Security and Defense, Emergency Management, Science, and commercial applications. Technology needs to be developed in order to reduce technical barriers for integrating UAS into the NAS. Currently, five subprojects for this category include: separation assurance/sense and avoid interoperability, communications, human systems integration, certification, and integrated test and evaluation.

## **Topic A3 Air Vehicle Technology**

### **A3.01 Structural Efficiency–Aeroservoelasticity**

The technical discipline of aeroelasticity is a critical ingredient necessary in the design process of a flight vehicle for ensuring freedom from catastrophic aeroelastic and aeroservoelastic instabilities. This discipline requires a thorough understanding of the complex interactions between a flexible structure and the unsteady aerodynamic forces acting on the structure and at times, active systems controlling the flight vehicle. The Fundamental Aeronautics Program's work on Structural Efficiency for the FY 2014 NASA SBIR solicitation is focused on aeroservoelasticity active structural control for lightweight flexible structures.

### **A3.02 Quiet Performance**

Improve noise prediction, acoustic and relevant flow field measurement methods, noise propagation, and noise control for subsonic, transonic, and supersonic vehicles, specifically targeting airframe noise sources and the noise sources due to the aerodynamic and acoustic interaction of the airframe and engines.

### **A3.03 Low Emissions/Clean Power**

Achieves lower emissions and discover new paths to cleaner power for future air vehicles, which will be required to operate under more stringent regulations for gaseous and particulate emissions. The foundation for more efficient vehicles will be based on low emissions combustion processes which require very rapid mixing of the fuel and air with minimum pressure loss to achieve complete combustion in the smallest volume.

### **A3.04 Aerodynamic Efficiency**

NASA is conducting fundamental aeronautics research to develop innovative ideas that can lead to next generation aircraft design concepts with improved aerodynamic efficiency. Innovative vehicle concepts are being studied with emphasis on MDAO methods that can simultaneously address complex interactions among aerodynamics, aeroelasticity, propulsion, dynamics, and controls. There is an increasing interest in flight control technologies that can improve aerodynamic efficiency. Concepts such as performance adaptive aeroelastic wing shape control for drag reduction and circulation control for lift augmentation are potential aviation technologies that can contribute to the goal of aerodynamic efficiency.

### **A3.05 Physics-Based Conceptual Design Tools**

Investigates the potential of advanced, innovative propulsion and aircraft concepts to improve fuel efficiency and reduce the environmental footprint of future generations of commercial transports across the subsonic and supersonic flight regimes. Conceptual design and analysis of unconventional vehicle concepts and technologies is used for technology portfolio investment planning, development of advanced concepts to provide technology pull, and independent technical assessment of new concepts.

### **A3.06 Rotorcraft**

Develops technologies and tools to overcome barriers for rotary wing vehicles, including noise and carbon emissions. Noise technologies predict, measure, and characterize noise associated with vertical lift UAVs. To address the emissions problem, all-electric and hybrid electric propulsion systems should be developed to reduce the carbon emissions and fuel consumption.

### **A3.07 Propulsion Efficiency–Propulsion Materials and Structures**

Conducts novel research in materials and structures that enhance aircraft propulsion efficiency by reducing vehicle weight, fuel consumption, and increasing component durability/life. Research includes new materials such as high-temperature metals, alloys, ceramics, polymers, and their composites. Material systems and their interactions with harsh environmental conditions are of particular importance to develop more advanced materials for future systems.

## **Topic A4 Ground and Flight Test Techniques and Measurement**

### **A4.01 Ground Test Techniques and Measurement Technologies**

Ground-based testing resources emphasize the technological need to improve wind tunnel utilization. Develops innovative tools/technologies that enhance testing and measurement capabilities, improves ground test resource utilization and efficiency, and provides capability sustainment.

## **Phase I and II Contract Awards**

The number of Phase I and II contracts associated with ARMD are summarized in Table II and Table III.

TABLE II.—FISCAL YEAR 2015 PHASE I CONTRACT  
AWARDS ASSOCIATED WITH ARMD

Subtopic <sup>a</sup>	Awards
A1.01 Structural Efficiency-Hybrid Nanocomposites	2
A1.02 Aerodynamic Efficiency Drag Reduction Technology	3
A1.03 Low Emissions Propulsion and Power	4
A1.04 Quiet Performance	3
A1.05 Physics-Based Conceptual Aeronautics Design Tools	3
A1.06 Vertical Lift	2
A1.07 Efficient Propulsion and Power	2
A1.08 Ground Testing and Measurement Technologies	4
A2.01 Flight Test and Measurements Technologies	8
A2.02 Unmanned Aircraft Systems Technology	11
A3.01 Advanced Air Traffic Management Systems Concepts	6
A3.02 Autonomy of the National Airspace System	11
A3.03 Future Aviation Systems Safety	2

<sup>a</sup>See Appendix A for contract titles.

TABLE III.—FISCAL YEAR 2014 PHASE II CONTRACT  
AWARDS ASSOCIATED WITH ARMD

Subtopic <sup>a</sup>	Awards
A1.01 Aviation External Hazard Sensor Technologies	0
A1.02 Inflight Icing Hazard Mitigation Technology	0
A1.03 Real-Time Safety Assurance Under Unanticipated and Hazardous Conditions	2
A1.04 Prognostics and Decision Making	1
A1.05 Identification of Sequences of Atypical Occurrences in Massive Heterogeneous Datasets Representing the Operation of a System of Systems	0
A2.01 Unmanned Aircraft Systems Integration in the National Airspace System (NAS) Research	6
A3.01 Structural Efficiency–Aeroservoelasticity	2
A3.02 Quiet Performance	2
A3.03 Low Emission/Clean Power	1
A3.04 Aerodynamic Efficiency	1
A3.05 Physics-Based Conceptual Design Tools	1
A3.06 Rotorcraft	2
A3.07 Propulsion Efficiency–Propulsion Materials and Structures	2
A4.01 Ground Test Techniques and Measurement Technologies	5

<sup>a</sup>See Appendix B for contract titles

## ARMD Program and Project Summaries

FY 2015 and FY 2014 ARMD topics and subtopics strategically align with ARMD programs and projects, and support the directorate’s current needs and objectives. To help small business PIs and ARMD project managers, it is important to understand how the SBIR subtopics are mapped to ARMD programs and projects for FY15 and FY14, respectively, as shown in Figure 4 and Figure 5. ARMD program and project descriptions follow.





Figure 4.—FY 2015 Small Business Innovation Research topics and subtopics mapped to Aeronautics Research Mission Directorate programs and projects.

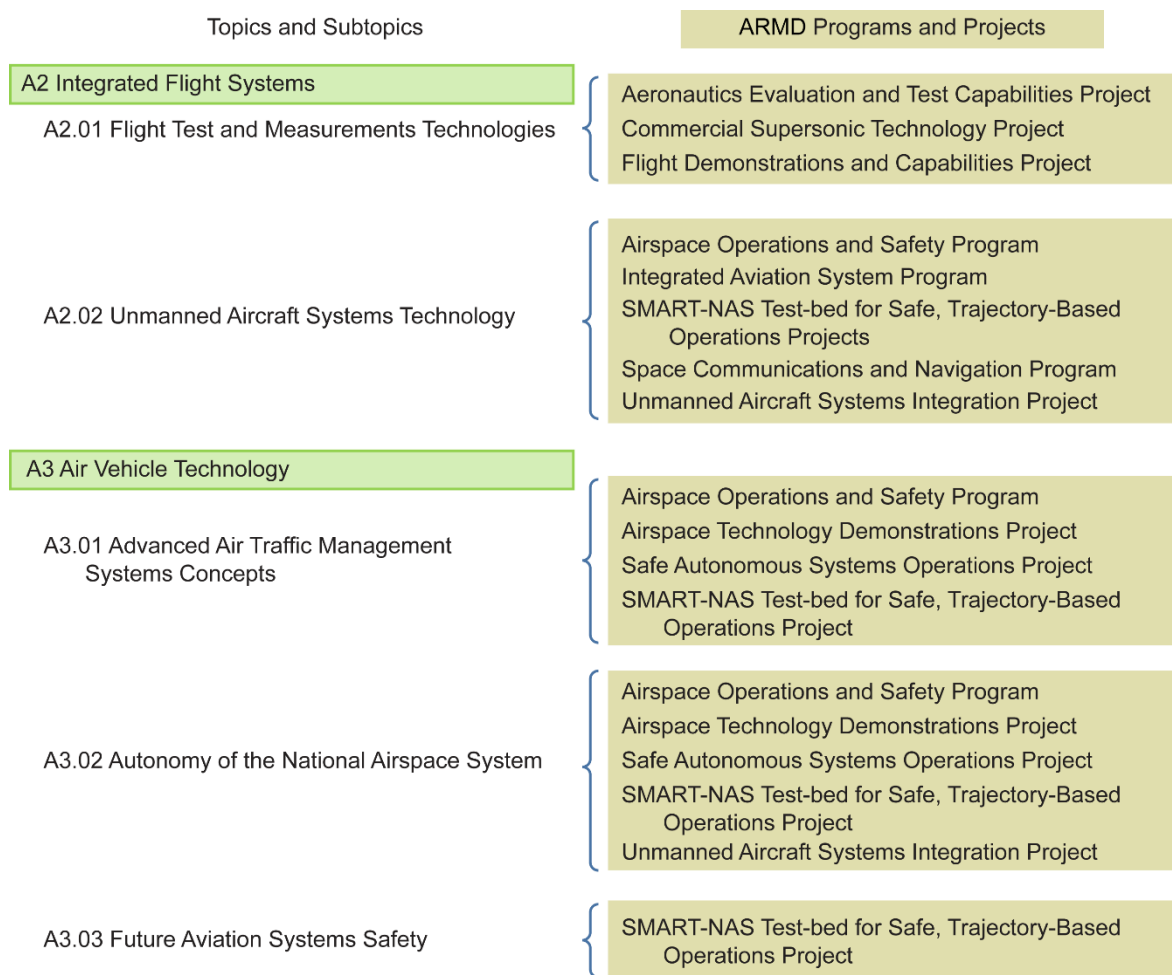


Figure 4.—Concluded.

Topics and Subtopics	ARMD Programs and Projects
<b>A1 Air Aviation Safety</b>	
A1.01 Aviation External Hazard Sensor Technology	Space Communications and Navigation Program
A1.02 Inflight Icing Hazard Mitigation Technology	Advanced Air Transportation Technology Project Advanced Air Vehicle Program Evaluation and Test Capabilities Project
A1.03 Real-Time Safety Assurance Under Unanticipated and Hazardous Conditions	Airspace Operations and Safety Program Airspace Technology Demonstrations Project Safe Autonomous Systems Operations Project
A1.04 Prognostics and Decision Making	Advanced Exploration Systems Program Airspace Operations and Safety Program Safe Autonomous Systems Operations Project
<b>A2 Unmanned Aircraft Systems</b>	
A2.01 Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Research	SMART-NAS Test-bed for Safe, Trajectory-Based Operations Project Unmanned Aircraft System Integration Project
<b>A3 Air Vehicle Technology</b>	
A3.01 Structural Efficiency–Aeroservoelasticity	Advanced Air Transportation Technology Project Advanced Air Vehicle Program Aeronautics Evaluation and Test Capabilities Project Commercial Supersonic Technology Project Transformative Aeronautics Concepts Program
A3.02 Quiet Performance	Advanced Air Transportation Technology Project Commercial Supersonic Technology Project Environmentally Responsible Aviation Project
A3.03 Low Emissions and Clean Power	Advanced Air Transportation Technology Project Transformational Tools and Technologies Project
A3.05 Physics-Based Conceptual Design Tools	Environmentally Responsible Aviation Project Revolutionary Vertical Lift Technologies Project
A3.06 Rotorcraft	Convergent Aeronautics Solutions Project Revolutionary Vertical Lift Technologies Project
A3.07 Propulsion Efficiency Propulsion Materials and Structures	Transformational Tools and Technologies Project
<b>A4 Ground and Flight Test Techniques and Measurement</b>	
A4.01 Ground Test Techniques and Measurement Technologies	Advanced Air Transportation Technology Project Aeronautics Evaluation and Test Capabilities Project

Figure 5.—FY 2014 Small Business Innovation Research topics and subtopics mapped to Aeronautics Research Mission Directorate programs and projects.

## **Advanced Air Transportation Technology Project**

Explores and develops technologies for advanced fixed-wing transport aircraft with revolutionary energy efficiency. These technologies are critical to reduce the environmental impact of aviation as the industry continues to grow. Advanced Air Transportation Technologies studies focus on the future and target vehicles that are three generations beyond the current state of the art that require mature technology solutions in the 2025 to 2035 timeframe.

## **Advanced Air Vehicle Program**

More environmentally friendly next-generation fixed-wing and vertical lift aircraft will be needed as both domestic and international air transportation growth accelerates. The Advanced Air Vehicle Program studies, evaluates, and develops technologies and capabilities that can be integrated into these aircraft systems as well as exploring far-future concepts that hold promise for revolutionary improvements to air travel.

## **Advanced Composites Project**

The Advanced Composites Project is developing key technologies that will reduce the timeline for development and certification of innovative composite structural components, which will help American industry retain their global competitive advantage in aircraft manufacturing.

## **Advanced Exploration Systems Program**

This program is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. AES activities are uniquely related to crew safety and mission operations in deep space, and are strongly coupled to future vehicle development.

## **Aeronautics Evaluation and Test Capabilities Project**

Sets the strategic direction for NASA's versatile and comprehensive portfolio of ground test aeronautics research capabilities. Its integrated approach to asset planning, use, and management will consider the complementary high-end computing capabilities necessary for advanced analyses in conjunction with the ground experimentation capabilities.

## **Airspace Operations and Safety Program**

The Airspace Operations and Safety Program creates technologies to help NextGen fulfill its promise by working with the Federal Aviation Administration, industry, and academic partners to develop NextGen technologies to improve the intrinsic safety of current and future aircraft.

## **Airspace Technology Demonstrations Project**

The Airspace Technology Demonstrations (ATD) Project is comprised of a collection of critical technology development and demonstration activities geared toward delivery of near-term benefits to air transportation system stakeholders. Several activities under this effort include (1) Terminal Sequencing and Spacing – Flight Deck Interval Management, (2) Integrated Arrival/Departure/Surface, (3) Applied

Traffic Flow Management (ATFM), and (4) Technologies for Airplane State Awareness (Energy and Attitude).

### **Commercial Supersonic Technology Project**

Develops tools, technologies, and methods to help eliminate barriers to practical commercial supersonic flight: sonic boom, fuel efficiency, airport community noise, high-altitude emissions, structural weight, and flexibility, and airspace operations. Focuses mainly on sonic boom reduction methods and approaches.

### **Convergent Aeronautics Solutions Project**

Merges traditional aeronautics disciplines with advancements driven by the non-aeronautics world to improve capabilities in commercial aviation. CAS teams conduct initial feasibility studies, perform experiments, try out new ideas, identify failures, and then review whether developed solutions have met their goals and whether they are feasible options in the real world.

### **Environmentally Responsible Aviation Project**

Explores and documents the feasibility, benefits, and technical risk of vehicle concepts and enabling technologies to reduce aviation's impact on the environment. Assesses new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions.

### **Flight Demonstrations and Capabilities Project**

The Flight Demonstrations and Capabilities (FDC) Project conducts complex and integrated small-scale flight research demonstrations in support the ARMD programs. In addition, FDC operates, sustains and enhances those specific flight research and test capabilities necessary to address and achieve the ARMD Strategic Plan, ARMD program/project activities, other NASA mission directorate activities and national strategic needs.

### **Game Changing Development Program**

This program advances space technologies that may lead to entirely new approaches for the Agency's future space missions and provide solutions to significant national needs. The program will focus efforts in the mid Technology Readiness Level (TRL) range of (3-5/6) generally taking technologies from proof of concept through component or breadboard testing in a relevant environment.

### **Integrated Aviation System Program**

The Integrated Aviation System Program conducts flight-oriented, integrated, system-level research and technology development that supports the flight research needs across the ARMD strategies, programs, and projects. The IASP focuses on highly complex flight tests and related experiments.

## **Revolutionary Vertical Lift Technologies Project**

Improves unique vertical capabilities by reducing noise and improving safety and fuel efficiency. RVLT research develops tools, technologies, and concepts that overcome performance barriers. These new technologies increase speed, range, and payload and decrease noise, vibration, fuel burn, and emissions by using improved computer-based prediction methods.

## **Safe Autonomous Systems Operations Project**

To address the needs of future air transportation and airspace operations, the Safe Autonomous Systems Operations (SASO) Project identifies and develops the maximum possible autonomous capabilities. Once the Next Generation Air Transportation System (NextGen) is implemented, airborne autonomy will likely expand. Operational complexity will increase to enable and sustain significant growth in passengers and cargo. The project's goal is to seek ways to safely integrate within the National Airspace System the highest level of automation that is justifiable, but not to explore automation simply for automation's sake.

## **SMART-NAS Testbed for Safe, Trajectory-Based Operations Project**

The SMART-NAS project develops an air traffic management simulation capability to integrate alternative concepts, technologies, and architectures into the NAS. Simulations will take actual operational input from the NAS by employing advanced prognostics, data mining, and data analytics for enhanced decision-making and system assessments.

## **Space Communications and Navigation Program**

The Space Communication and Navigation Program builds and maintains a scalable integrated mission support infrastructure that can accommodate new and changing technologies, while providing comprehensive, robust, cost-effective, and exponentially higher data rate space communications services to support NASA's science, space operations, and exploration missions.

## **Transformational Tools and Technologies Project**

Develops new computer-based tools, models, and associated scientific knowledge that will provide first-of-a-kind capabilities to analyze, understand, and predict performance for a wide variety of aviation concepts. Examples of research areas include predicting flow around vehicles and improving the understanding of strong and lightweight materials for aviation.

## **Transformative Aeronautics Concepts Program**

The Transformative Aeronautics Concepts Program cultivates multidisciplinary, innovative concepts to transform aviation. Although TACP focuses on sharply focused research, the program provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation. The program solicits and encourages revolutionary concepts, creates the environment for researchers to experiment with new ideas, performs ground and small-scale flight tests, allows failures and learns from them, and drives rapid turnover into potential future concepts.

## **Unmanned Aircraft Systems Integration Project**

Integrating UAS in the NAS project will provide research findings to reduce technical barriers associated with integrating UAS into the NAS. The barriers include a lack of sense-and-avoid concepts and technologies that can operate within the NAS, robust communication technologies, robust human systems integration, and standardized safety and certification guidelines.

## **Unmanned Aircraft Systems Traffic Management Project**

There is a compelling need to regulate civilian UAS air traffic to avoid collisions and ensure safety. The UTM project enables safe and efficient low altitude airspace operations by providing services such as airspace design, corridors, dynamic geofencing, preventing severe weather, wind, and terrain damage, congestion management, route planning and re-routing, separation management, sequencing and spacing, and contingency management.





## Appendix A.—Fiscal Year 2015 Phase I Contract Titles

The following Phase I contract abstracts are posted at <http://sbir.nasa.gov/SBIR/abstracts/15-1.html>

A1.01-9853	Benefit Analysis of Hybrid CNT/CFRP Composites in Future Aircraft Structures
A1.01-9678	Hybrid Nanocomposites for Efficient Aerospace Structures
A1.02-9373	Plasma Flow Control for Drag Reduction
A1.02-9438	Drag Reduction through Pulsed Plasma Actuators
A1.02-9677	Microblowing Technique for Drag Reduction
A1.03-9122	Cryogenic and Non-Cryogenic Hybrid Electric Distributed Propulsion with Integration of Airframe and Thermal Systems to Analyze Technology Influence
A1.03-9200	High Performance Carbon Nanotube Based Conductors
A1.03-9346	A New Cryocooler for MgB <sub>2</sub> Superconducting Systems in Turboelectric Aircraft
A1.04-9175	Shape Memory Alloy Adaptive Structures
A1.04-9178	Adjoint Techniques and Acoustic Three Zone Method for the Accurate Design of LowBoom Maneuvers (ATAtZM-DLBM)
A1.04-9214	Interferometric Correlator for Acoustic Radiation & Underlying Structural Vibration (ICARUSV)
A1.05-8776	Advanced Aerodynamic Analysis for Propulsion Airframe Integration
A1.05-9104	Physics-Based Aeroanalysis Methods for Open Rotor Conceptual Design
A1.05-9471	Physics-based MDAO tool for CMC blades and vanes conceptual design
A1.06-9338	Non-Contact Magnetic Transmission for Hybrid/Electric Rotorcraft
A1.06-9851	Vertical Lift by Series Hybrid Power
A1.07-9387	High Temperature “Smart” P3 Sensors and Electronics for Distributed Engine Control
A1.07-9813	Variable Fidelity AeroPropulsoServoElasticity Analysis Tool
A1.08-8885	Miniaturized Dynamic Pressure Sensor Arrays with Sub-Millimeter (mm) Spacing for Cross-Flow Transition Measurements
A1.08-9032	Plenoptic Flow Imaging for Ground Testing
A1.08-9052	Fast Pressure-Sensitive Paint System for Production Wind Tunnel Testing
A1.08-9770	3D Flow Field Measurements using Aerosol Correlation Velocimetry
A2.01-8721	Self-Nulling Schlieren Imaging for Aircraft in Flight
A2.01-8787	Rugged, Compact, and Inexpensive Airborne Fiber Sensor Interrogator Based on a Monolithic Tunable Laser
A2.01-8865	High Sensitivity Semiconductor Sensor Skins for Multi-Axis Surface Pressure Characterization
A2.01-8933	Integrated Optical Engine for Rugged, Compact, Inexpensive Airborne Fiber Sensor Interrogators
A2.01-9132	Robust Sensor for In-Flight Flow Characterization
A2.01-9411	Wireless Sensor Network for Flight Test
A2.01-9858	CloudTurbine: Streaming Data via Cloud File Sharing

A2.01-9961	A Novel Laser Ultrasound Visualization Tool for Non-destructive Evaluation of Composite Aircraft Structures
A2.02-8604	Onboard Model Checking for Small Scale Unmanned Aerial Vehicle Autopilots
A2.02-9001	Verification and Validation of Adaptive Learning Control System Towards Safety Assurance and Trusted Autonomy
A2.02-9059	Collision-avoidance radar for small UAS
A2.02-9071	A Low Cost, Secure Radio Communications System for UAVs
A2.02-9086	Development and Flight Testing of an Automated Upset Recovery System
A2.02-9371	Human Automation Teaming Testbed for Multi-UAS Management (M-HATT)
A2.02-9479	Fully-Automated, Agricultural Application using Unmanned Aircraft
A2.02-9594	Mission Planner for Dynamic Precision Based Navigation of Unmanned Aircraft Teams
A2.02-9634	Flight Testing of Resource Allocation for Multi-Agent Planning (ReMAP) System for Unmanned Vehicles
A2.02-9727	A Modular Swarm Optimization Framework Enabling Multi-Vehicle Coordinated Path Planning
A2.02-9786	Command and Control Software for Single-Operator Multiple UAS Missions
A3.01-8620	A SMART NAS Toolkit for Optimality Metrics Overlay
A3.01-8953	Airport Gate Activity Monitoring Tool Suite for Improved Turnaround Prediction
A3.01-9007	360-Degree Analysis Engine for Autonomous NAS Operations and Control
A3.01-9208	Trajectory-Based Operations (TBO) Cost Estimation
A3.01-9499	Networked ATM for Efficient Routing
A3.01-9583	TFM Performance Monitoring and Review System
A3.02-8660	A Framework for Autonomous Trajectory-Based Operations
A3.02-8745	3D Flash LIDAR All-Weather Safety
A3.02-8949	Autonomous Airport Operations for Safe and Efficient Use of Airports
A3.02-8950	Generic FMS Platform for Evaluation of Autonomous Trajectory-Based Operation Concepts
A3.02-8996	Application of Imaging Sensors for UAS Command and Control for Evolving Towards Autonomous Operations of UAS
A3.02-9077	Autonomous, Safe Take-Off and Landing Operations for Unmanned Aerial Vehicles in the National Airspace
A3.02-9153	Verification & Validation of Complex Autonomy Concepts Using the Cloud
A3.02-9395	Auto-Suggest Capability via Machine Learning in SMART NAS
A3.02-9408	Convective Induced Turbulence Detection in Oceanic Trajectory-Based Operations
A3.02-9414	Anomaly Detection to Improve Airspace Safety and Efficiency
A3.02-9466	Weather Aware Route Planning (WARP)
A3.02-9593	Probabilistic Trajectory Constraint Modeler
A3.02-9595	Wind Shift Detection Model
A3.02-9598	Advanced Modeling of Ramp Operations including Departure Status at Secondary Airports
A3.03-8717	Transported Turbulence During Climb, Cruise and Descent
A3.03-8942	Big Data Driven Architecture for Real Time System wide Safety Assurance

## Appendix B.—Fiscal Year 2014 Phase II Contract Abstracts

The following Phase II Phase II contract abstracts are posted at <http://sbir.nasa.gov/SBIR/abstracts/14-2.html>

A1.03-9133	Virtual Redundancy for Safety Assurance in the Presence of Sensor Failures
A1.03-9134	Damage Adaptive Guidance for Piloted Upset Recovery
A1.04-8768	Handheld Electronics EHM Sensor Probe for Determination of Remaining Useful Life
A1.04-9455	Diagnosis-Driven Prognosis for Decision Making
A2.01-8766	ASPECT (Automated System-level Performance Evaluation and Characterization Tool)
A2.01-9144	UAS Demand Generator for Discrete Airspace Density
A2.01-9219	SOAR - Stereo Obstacle Avoidance Rig
A2.01-9239	UAS Power Amplifier for Extended Range of Non-Payload Communication Devices (UPEND)
A2.01-9452	A Compact, Wide Area Surveillance 3D Imaging LIDAR Providing UAS Sense and Avoid Capabilities
A2.01-9910	Non-Parametric, Closed-Loop Testing of Autonomy in Unmanned Aircraft Systems
A3.01-9708	Nonlinear Parameter-Varying AeroServoElastic Reduced Order Model for Aerostructural Sensing and Control
A3.01-9973	Linearized FUN3D for Rapid Aeroelastic and Aeroservoelastic Design and Analysis
A3.02-9794	Phased Array Technique for Low Signal-To-Noise Ratio Wind Tunnels
A3.02-9830	Adaptive Liners for Broadband Noise Reduction
A3.03-9123	Compact Kinetic Mechanisms for Petroleum-Derived and Alternative Aviation Fuels
A3.04-9214	Drag Identification & Reduction Technology (DIRECT) for Elastically Shaped Air Vehicles
A3.05-8588	Physics-Based Conceptual Design Tools
A3.06-9367	Hybrid-Electric Rotorcraft Tool Development, Propulsion System Trade Space Exploration, and Demonstrator Conceptual Design
A3.06-9495	Hybrid Electric Propulsion System for a VTOL/Multirotor Aircraft
A3.07-8783	Robust High Temperature Environmental Barrier Coating System for Ceramic Matrix Composite Gas Turbine Components using Affordable Processing Approach
A3.07-9218	Cavitation Peening of Aerospace Bearings
A4.01-8643	High-Speed, Noninvasive, Multi-Parameter Laser Diagnostics for Transonic Flows
A4.01-8744	Oxygen-Independent Pressure Sensitive Paint
A4.01-8764	Versatile Sensor for Transition, Separation, and Shock Detection
A4.01-9539	Development of a “Digital Bridge” Thermal Anemometer for Turbulence Measurements
A4.01-9869	High Temperature Fiberoptic Thermal Imaging System

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4. Comstock, D.A.: Technology Development and Infusion From NASA's Innovative Partnerships Program. 2008 IEEE Aerospace Conference, Big Sky, MT, 2008, pp. 1–11.



